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Chapter 6

Uncertainties in Irradiance Calibrations

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Abstract

Three types of experiments were conducted to estimate the uncertainties associated with irradiance calibrations using an FEL standard lamp: a) the repeatability uncertainty (based on one FEL standard lamp used during 11 trials with three different irradiance sensors) was less than 0.5% (0.2% on average, with usually larger uncertainties in the blue part of the spectrum and smaller uncertainties in the red); b) the additional uncertainty that can be removed from radiance calibrations if ambient rather than dark measurements are used was 0.05% (0.05% in the blue, 0.04% in the green, and 0.06% in the red); and c) the overall uncertainty from secondary reflections, originating from ancillary equipment used during the calibration process (in this case, an alignment laser) was 0.06% (0.03% in the blue–green wavelength domain and 0.12% in the red).

6.1 INTRODUCTION

Typically, the calibration coefficients for an irradiance sensor (identified by $S_{\rm ID}$) are computed using an FEL standard lamp ($L_{\rm ID}$) with a calibrated irradiance, $E^{\rm cal}_{L_{\rm ID}}(\lambda, 50)$. The general procedures require the lamp to be positioned a distance d on axis and normal to the faceplate of the irradiance sensor (Sect. 1.5.7). The irradiance sensor is capped, and dark (digital voltage) levels for the sensor are recorded from which average dark levels, $\bar{D}_{S_{\rm ID}}(\lambda)$, are calculated.

The lamp is powered on, and the voltage levels of the individual sensor channels are recorded, from which an average calibration voltage for each channel, $\bar{V}_{S_{\rm ID}}(\lambda)$, is obtained. The calibration coefficient is calculated using:

$$C^{\rm Irr}_{S_{\rm ID}}(\lambda) \;=\; \frac{E^{\rm cal}_{L_{\rm ID}}(\lambda, 50)}{\bar{V}_{S_{\rm ID}}(\lambda) - \bar{D}_{S_{\rm ID}}(\lambda)} \left[\frac{50\ {\rm cm}}{d}\right]^2, \qquad (14)$$

where d is given in centimeters.

Three types of experiments were conducted to explore the uncertainties associated with irradiance calibrations:

a) The same FEL standard lamp was used with three OCI-200 radiometers to estimate the repeatability uncertainty in irradiance calibrations (based on 11 trials for each sensor);

b) The importance of ambient versus dark measurements was explored with three OCI-200 sensors; and

c) The uncertainty associated with reflections from improperly baffled ancillary equipment used in the calibration process (in this case, an alignment laser) was measured with three OCI-200 sensors.

6.2 IRRADIANCE REPEATABILITY

This experiment was designed to estimate the uncertainties in irradiance calibrations (set up and executed following the usual procedures). Three OCI-200 sensors (I040, I050, and I097) were calibrated independently 11 times each. Although the trials were all executed with the same FEL standard lamp, the lamp was not powered on and off for each trial; it was left on to minimize the amount of time used with the lamp (standard FEL lamps are too expensive to include the warm-up time for each trial in the experiment).